WG E: THEORY PART

- NuTeV:
  K. Diener Electroweak Corrections

- NLO Results:
  A. Serbio–Vera W @ large p_T
  N. Kidonakis Anomalous Top Couplings
  Charged Higgs Production
  M. Spira $b\bar{b}H$ @ NLO

- I. Melo Strong EWSB @ e^+e^-

- Automatic Tools:
  M. Moretti ALPGEN
  F. Krauss AMEGIC++ amd SHERPA

- T. Teubner $(g-2)_\mu$

The NuTeV Result for $\sin^2\theta_W$ - a Reanalysis of the Electroweak Radiative Corrections

K.-P. O. Diener*
Paul Scherrer Institut

DIS04, April 15, 2004

*in collaboration with S. Dittmaier and W. Hollik

conclusions

- issues/subtleties in $\mathcal{O}(\alpha)$ corrections:
  in δR^{ν}_{NC}: $\Pi^{\gamma Z}_{T}(0)$
  initial state mass factorization
  treatment of final state collinear photons

- absolute uncertainties in $\sin^2\theta_W$:
  input parameter scheme: $\approx 5 \cdot 10^{-4}$
  cut on final state energy: $< 4 \cdot 10^{-3}$
  $(5 \cdot 10^{-3}$ to resolve discrepancy)

- NuTeV for total theory error: $5 \cdot 10^{-5}$
  off by more than an order of magnitude!

- BD results not reproduced — systematic problem?

- still open questions

- NuTeV error should be reanalyzed

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results of tuned comparison with BD
(energy cut on hadronic final state)

Hadronic energy cut: $E_{q'} > 10\,\text{GeV}$

IPS	FS	R_0^ν	δR^ν_{NC}	δR^ν_{CC}	$\Delta \sin^2\theta_W$
result of BD	BD	–	−0.0021	−0.0223	−0.0114
G_F	$\overline{\text{MS}}$	0.31455	0.0010	−0.0202	−0.0090
G'_F	$\overline{\text{MS}}$	0.33113	−0.0018	−0.0186	−0.0095
G_F	BD	0.31455	−0.0026	−0.0184	−0.0098
G'_F	BD	0.33113	−0.0050	−0.0169	−0.0103

$\rightarrow$ absolute dependence on FS $< 8 \cdot 10^{-4}$
$\rightarrow$ input parameter scheme dep. $< 5 \cdot 10^{-4}$
$\rightarrow$ energy cut dep. $< 4 \cdot 10^{-3}$ (not shown)
$\rightarrow$ BD result not reproduced
systematic deviations in $\delta R^\nu_{NC/CC}$?

Motivation:

• W boson production in hadron colliders as a test of the Standard Model and to estimate backgrounds to new physics.
(e.g. $Wb\bar{b}$ production as background
to the associated Higgs boson production
$p\bar{p} \to H(\to b\bar{b})W$ at the Tevatron
Ellis–Veseli(1999))

Background:

• The NLO cross section for W hadroproduction at large transverse momentum done by Arnold–Reno(1989) Gonsalves–Pawlowski–Wai(1989).

Production near threshold

Define $s=(p_b+p_g)^2$, $t=(p_b-p_t)^2$, $u=(p_g-p_t)^2$

and $s_4=s+t+u-m_t^2-m_{H^-}{}^2$

At threshold $s_4 \to 0$

Soft corrections $\left[\frac{\ln^l(s_4/m_{H^-}{}^2)}{s_4}\right]_+$

Virtual corrections $\delta(s_4)$

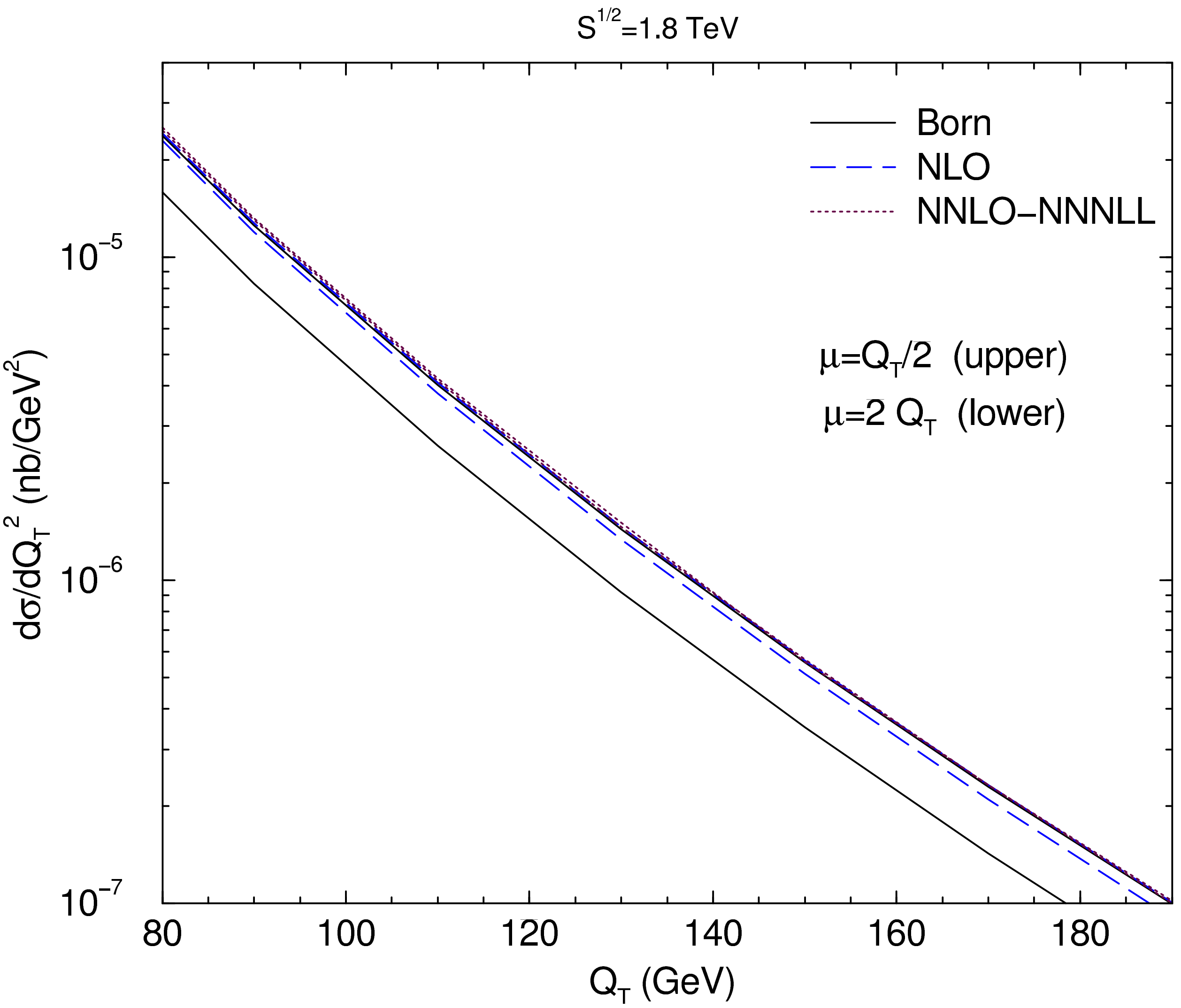
For the order α_s^n corrections $l \le 2n-1$

LL: l=2n-1

NLL: l=2n-2

Calculate NLO and NNLO corrections at NLL accuracy

$p\bar{p}$ –> W



The differential cross section, $d\sigma/dQ_T^2$, for W hadroproduction in $p\bar{p}$ collisions at the Tevatron with $\sqrt{S} = 1.8$ TeV and $\mu \equiv \mu_F = \mu_R = Q_T/2$ or $2Q_T$. Shown are the Born (solid lines), NLO (long-dashed lines), and NNLO-NNNLL (dotted lines) results. The upper lines are with $\mu = Q_T/2$, the lower lines with $\mu = 2Q_T$.

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Anomalous tqV couplings and FCNC top quark production

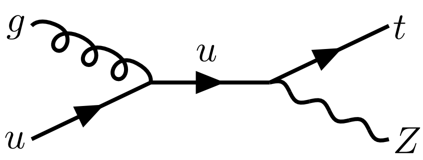
Nikolaos Kidonakis

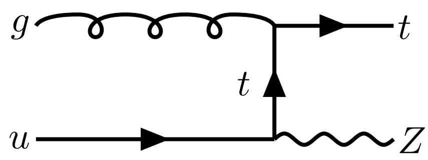
(University of Cambridge)

- Flavor-changing neutral-current processes
- Higer-order soft-gluon corrections
- $gu \to tZ$ at the Tevatron
- $gu \to t\gamma$ at the Tevatron
- $uu \to tt$ at the Tevatron
- $eu \to et$ at HERA

N. Kidonakis and A. Belyaev, JHEP 12, 004 (2003)

$gu \to tZ$

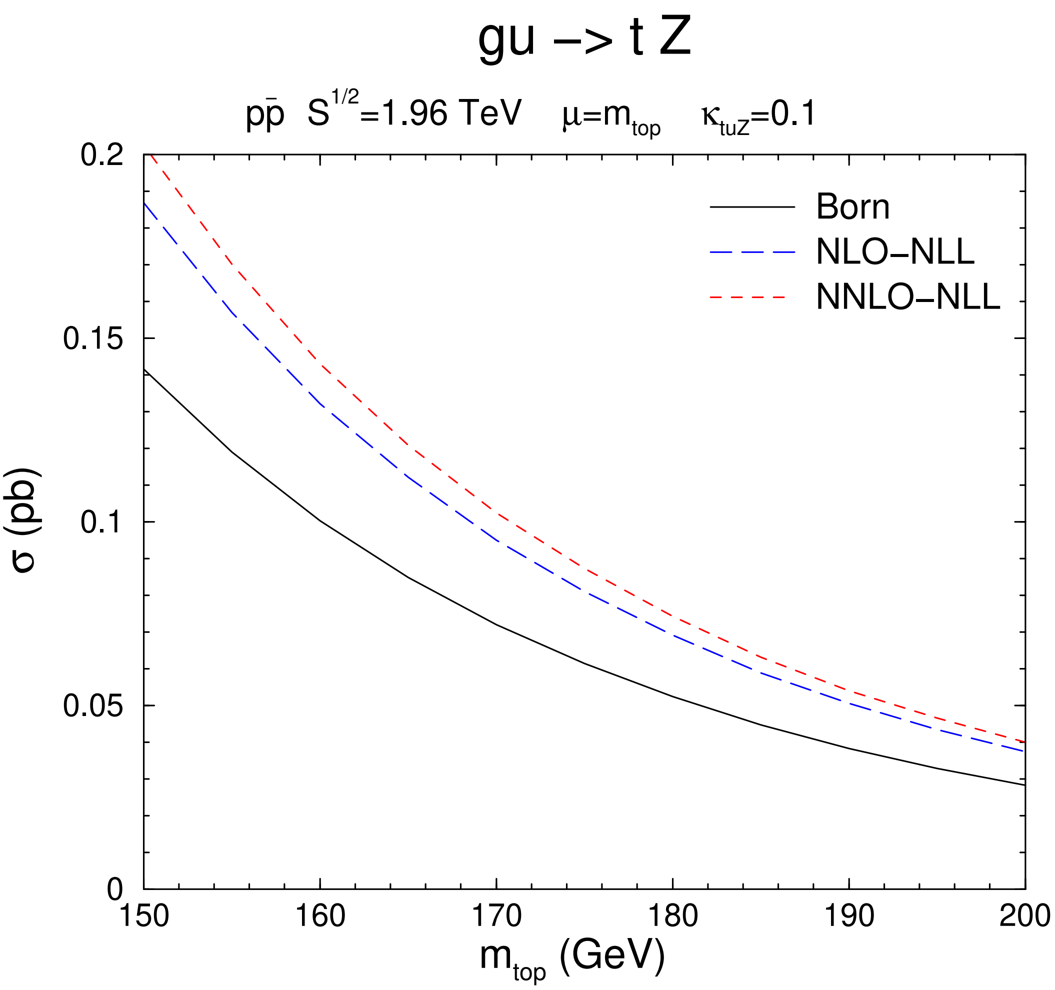


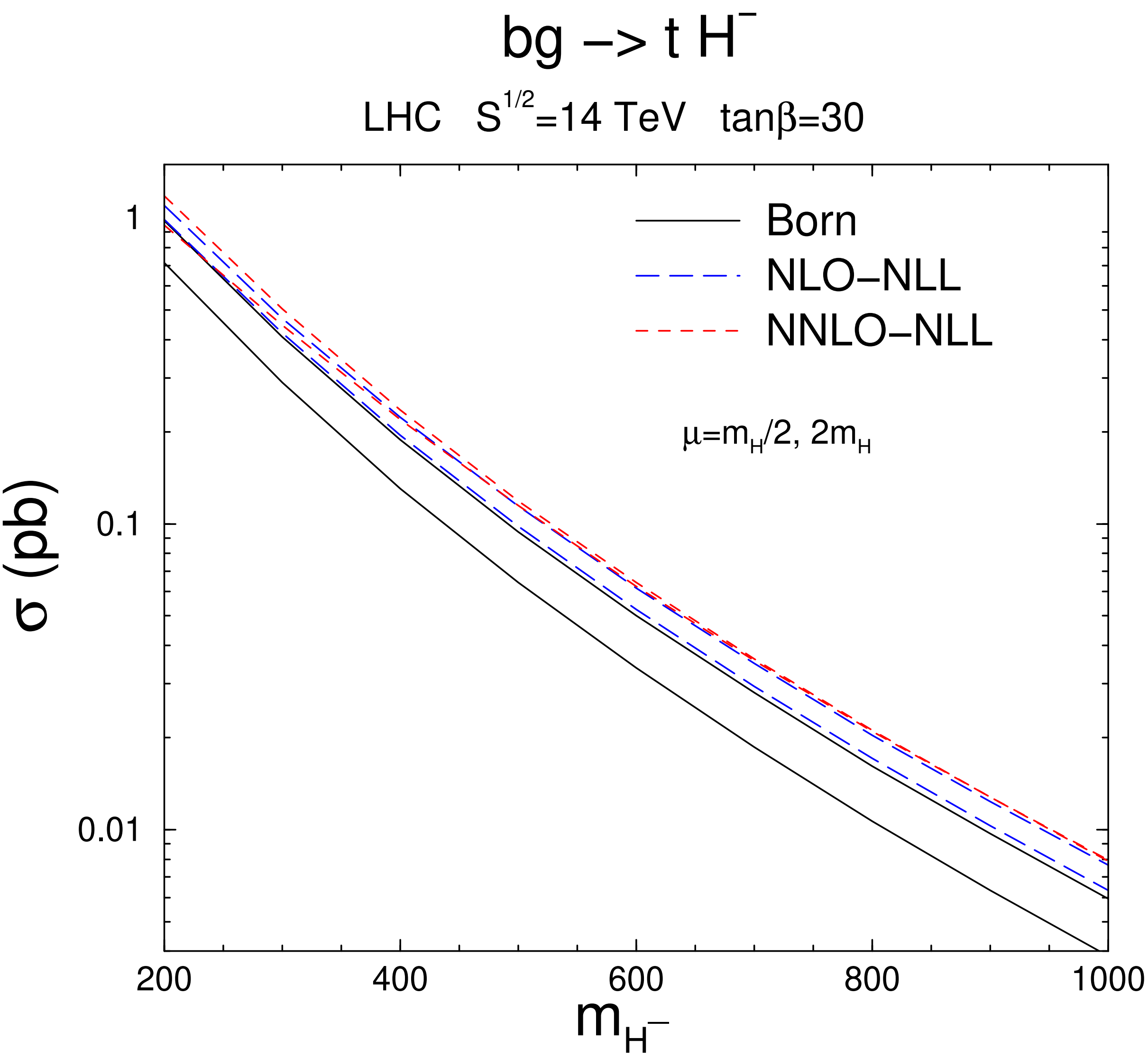


$$g(p_g) + u(p_u) \to t(p_t) + Z(p_Z)$$

$$s = (p_g + p_u)^2,\ t = (p_g - p_t)^2,\ u = (p_u - p_t)^2, \text{ and}$$

$$s_4 = s + t + u - m^2 - m_Z^2$$

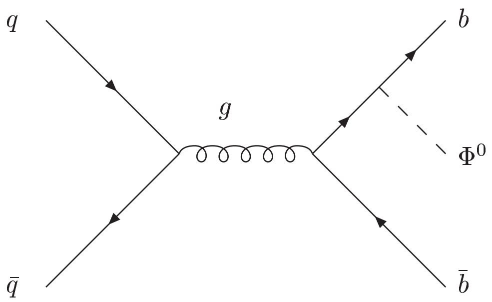


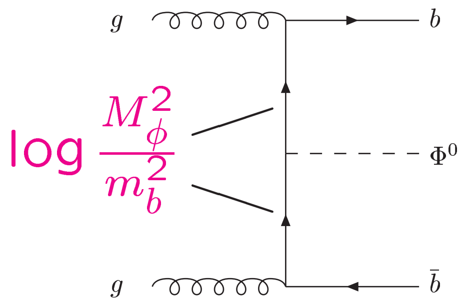


bg −> t H⁻
LHC S^{1/2}=14 TeV tanβ=30
Born
NLO−NLL
NNLO−NLL
μ=m_H/2, 2m_H
σ (pb)
1
0.1
0.01
200
400
600
800
1000
m_{H⁻}

M. Spira

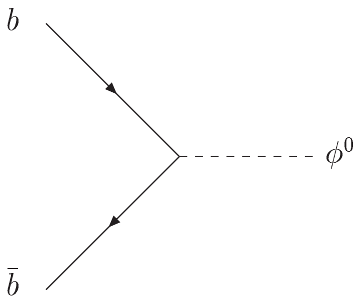
III *b DENSITIES*



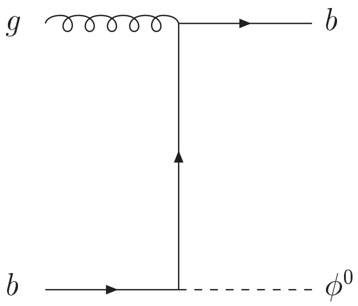


large logs from phase space integration
$\longrightarrow$ absorbed in bottom PDF
resummation $\equiv$ DGLAP evolution

- new processes:



NNLO



NLO

Dicus,Willenbrock
Stelzer, . . .
Balazs,. . .
Campbell,. . .

Harlander, Kilgore

$$b(x,\mu^2) \longrightarrow b(x,\mu^2) - \frac{\alpha_s}{2\pi} P_{qg} \otimes g(x,\mu^2) \log \frac{\mu^2}{m_b^2}$$

$$\mu \sim M_\phi \Rightarrow \sigma_{tot}$$

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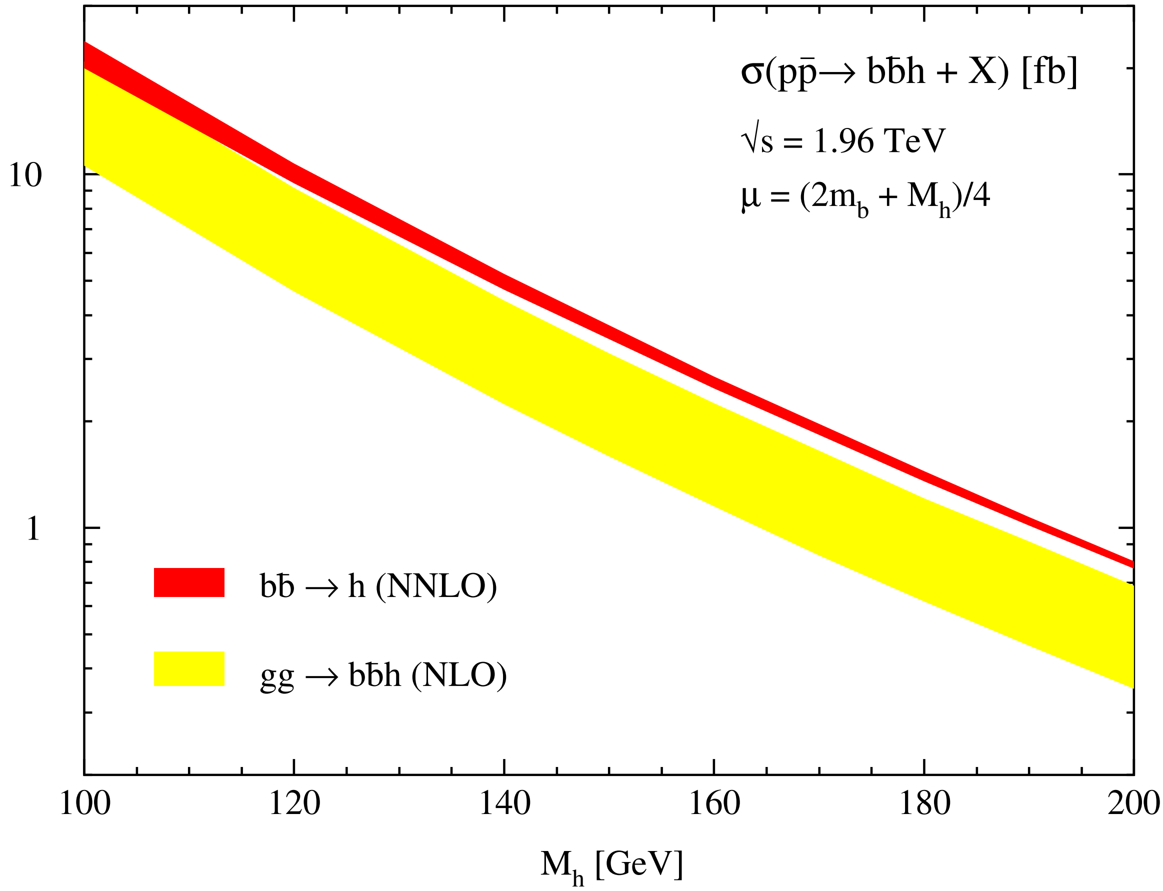
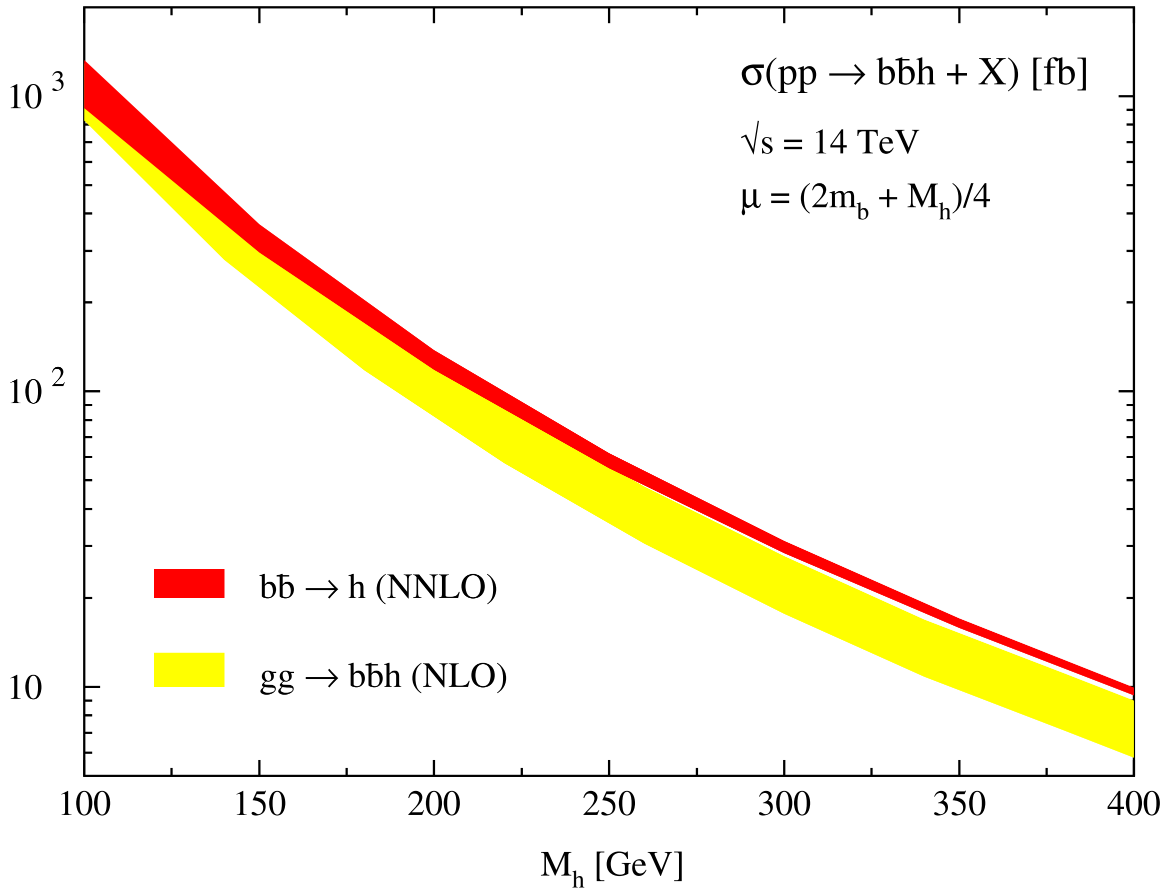




Dittmaier, Krämer, S.

Harlander, Kilgore

IV CONCLUSIONS

- $b\bar{b}H/A$ production important for large tgβ

- determination of tgβ

- QCD corrections: $\sim (40 - 100)\%$ at LHC

- agreement with S. Dawson, C. Jackson, L. Reina, D. Wackeroth, hep-ph/0311067

- large QCD corrections $\leftrightarrow$ b densities?
  [reasonable agreement of both approaches]

- reduction of scale dependence:
  $\Delta \lesssim 10 - 15\%$ for p_{Tb} and $p_{T\bar{b}} > 20$ GeV
  $\Delta \lesssim 20 - 30\%$ without cuts

- next steps:
  $b\bar{b}A$ production in MSSM
  SUSY-QCD corrections

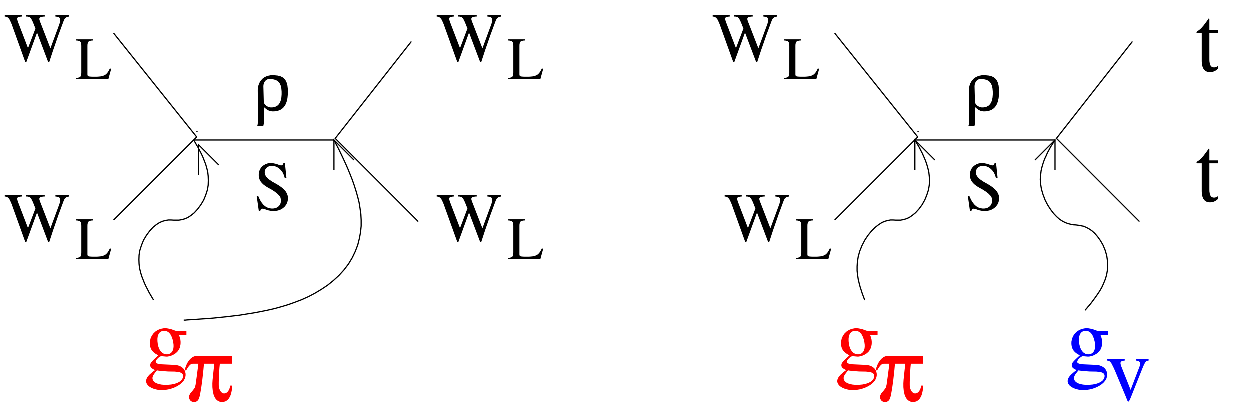
DIS 2004

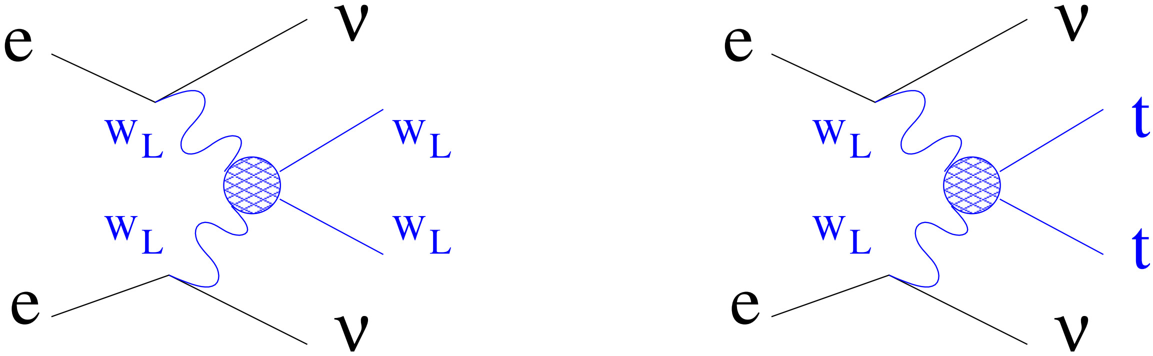
Vector resonances from strong electroweak symmetry breaking at e^+e^- colliders

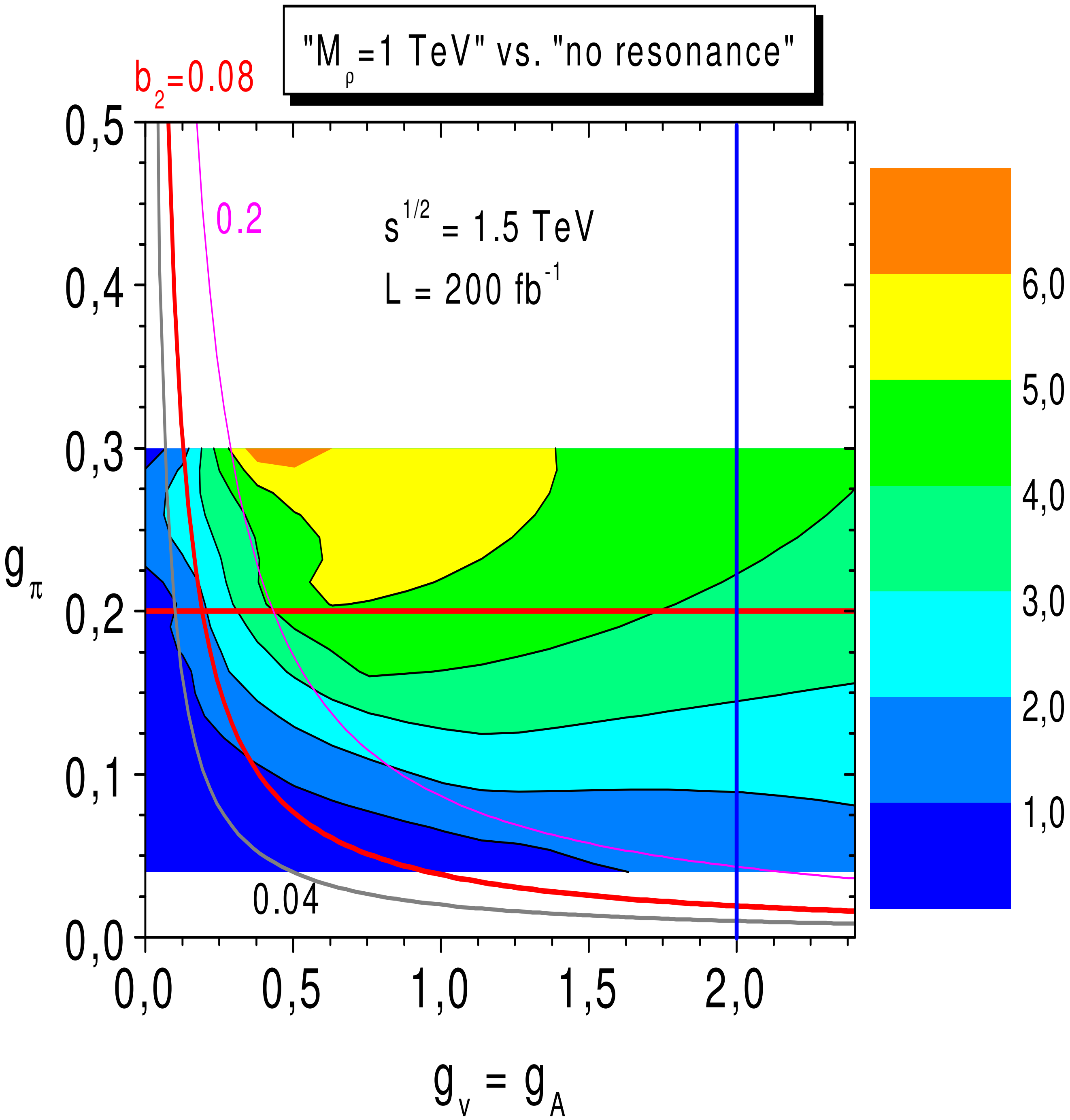
Ivan Melo

D. Bruncko (IEP SAS Kosice)
M. Gintner (University of Zilina)
I.Melo (University of Zilina)

$W_L W_L \to t\bar{t}$ scattering






"M ρ =1 TeV" vs. "no resonance"
b 2=0.08
0.2
s 1/2 = 1.5 TeV
L = 200 fb -1
0.04
g π
g V = g A
0,0
0,1
0,2
0,3
0,4
0,5
0,5
1,0
1,5
2,0
1,0
2,0
3,0
4,0
5,0
6,0

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ALPGEN

http://mlm.home.cern.ch/mlm/alpgen

M. Mangano, M. Moretti, R. Pittau, F. Piccinini and A. Polosa

JHEP 0307:001,2003.

- Ready-to-use exact LO calculation (based on the ALPHA code) for multiparton final states in hadronic collisions (SM)

  ALPHA: F. Caravaglios and M. Moretti, Phys. Lett. B **358** (1995) 332

- Parton-level event generation (weighted and unweighted)
  - mass term included
  - stable/ustable heavy particles avaliable.
  - routines for decays of heavy particles avaliable. full spin correlation in the narrow width approximations
  - coulor structure of the event in the leading $1/N_c$ approximation
- Interface to Herwig/Pythia for the evolution of the partonic final state through parton shower (jets and hadrons)

Validation against data

- Tevatron W + multi-jet data

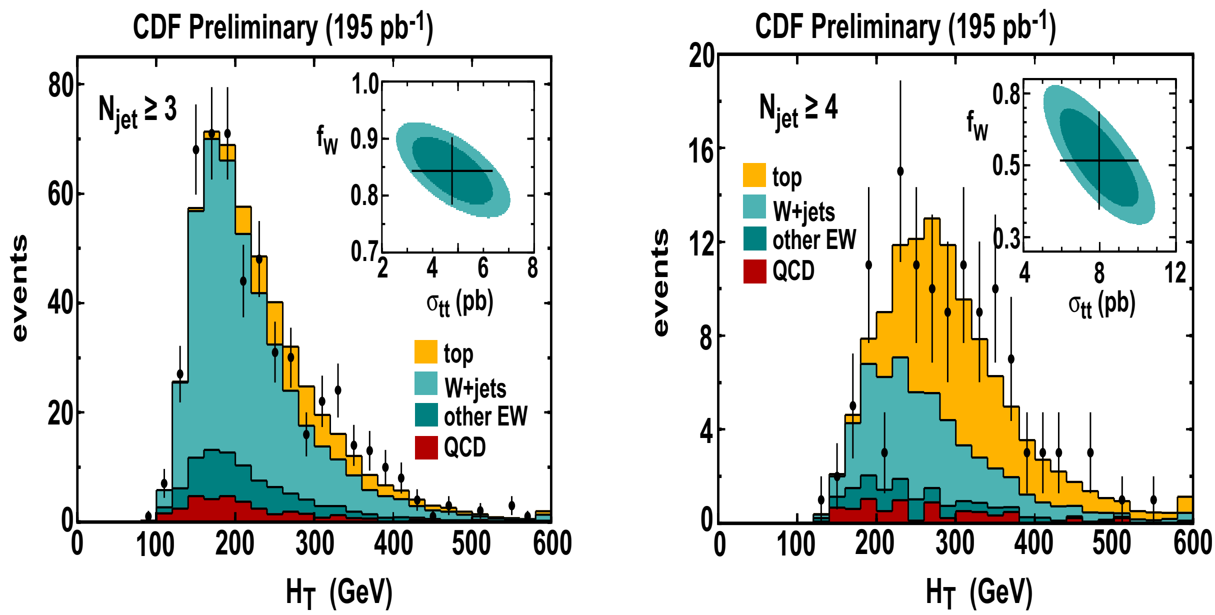


Figure 1:

New tools for automatic cross section calculation

Frank Krauss

Institute for Theoretical Physics, TU Dresden

Amplitude generation

Tame the factorial growth: “Super-amplitudes”

$e^+e^- \to$	Feynman diagrams	Super-amplitudes
e^+e^-	4	4
$e^+e^-\mu^+\mu^-$	50	10
$e^+e^-e^+e^-$	144	9
$e^+e^-e^+e^-\mu^+\mu^-$	3690	261
$e^+e^-e^+e^-e^+e^-$	13896	323

Idea: Factorise out common Helicity building blocks of different amplitudes

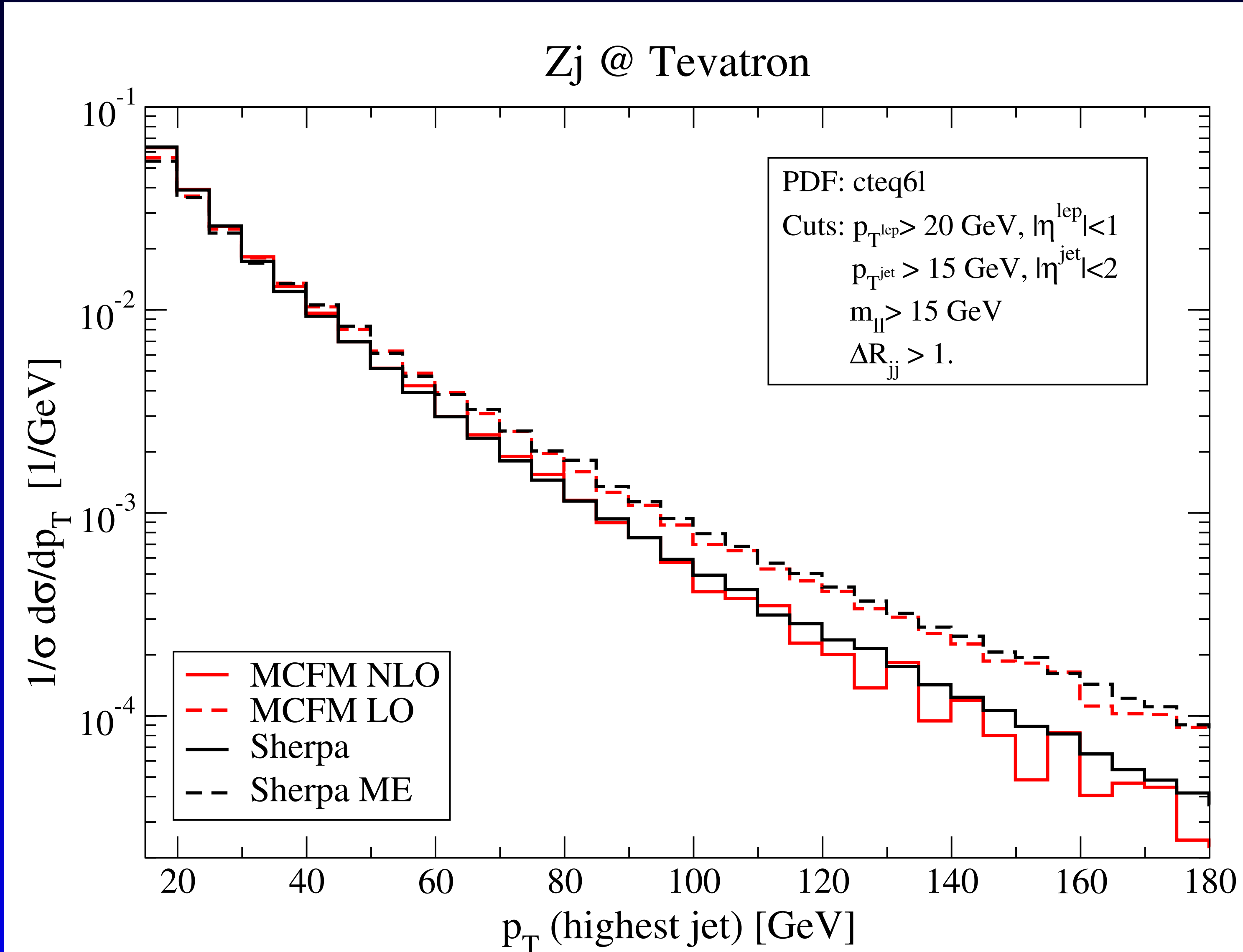
$\Rightarrow$ reduce the number of complex multiplications

Results with AMEGIC++

X-sects (pb)	Number of jets						
$e^- \bar{\nu}_e + n$ QCD jets	0	1	2	3	4	5	6
Alpgen	3904(6)	1013(2)	364(2)	136(1)	53.6(6)	21.6(2)	8.7(1)
CompHEP	3947.4(3)	1022.4(5)	364.4(4)				
MadEvent	3902(5)	1012(2)	361(1)	135.5(3)	53.6(2)		
Amegic++/Sherpa	3908(3)	1011(2)	362(1)	137.5(5)	54(1)		

X-sects (pb)	Number of jets				
$e^- \bar{\nu}_e + b\bar{b}$	0	1	2	3	4
Alpgen	9.34(4)	9.85(6)	6.82(6)	4.18(7)	2.39(5)
CompHEP	9.415(5)	9.91(2)			
MadEvent	9.32(3)	9.74(1)	6.80(2)		
Amegic++/Sherpa	9.37(1)	9.86(2)	6.87(5)		

Results: CKKW vs. NLO (I)



The different contributions numerically (up to date!):

T. Teubner

Source	contr. to $a_\mu \times 10^{11}$	remarks
QED	$116\ 584\ 719.35 \pm 1.43$	up to 5-loop! (Laporta+Remiddi, Kinoshita et al.)
	(was $116\ 584\ 705.7 \pm 1.8$)	▶ incl. most recent corr. from Kinoshita+Nio
EW	154 ± 2	2-loop, Czarnecki+Marciano+Vainshtein
		▶ agrees very well with Knecht+Peris+Perrottet+deRafael
LO hadr.	$7110 \pm 50 \pm 8 \pm 28$	Davier+Eidelman+Hoecker+Zhang '03b (τ)
(CMD-2 $\pi\pi$	$6963 \pm 62 \pm 36$	Davier+Eidelman+Hoecker+Zhang '03b (e^+e^-)
data re-anal.)	$6924 \pm 59 \pm 24$	Hagiwara+Martin+Nomura+T, hep-ph/0312250
NLO hadr.	-98 ± 1	HMNT, in agreem. with Krause '97, Alemany+D+H '98
L-by-L	136 ± 25	new: Melnikov+Vainshtein, hep-ph/0312226
< Dec. 2003:	80 ± 40	compilation from Nyffeler, hep-ph/0203243
< Nov. 2001:	(-85 ± 25)	the 'famous' sign error, $2.6\,\sigma \to 1.6\,\sigma$
$\sum$	$(11659183.5 \pm 6.7)10^{-10}$	with HMNT (e^+e^-)
Exp.:	$(11\ 659\ 208 \pm 6) \cdot 10^{-10}$	New BNL E821 world average 2004
$a_\mu^{EXP} - a_\mu^{TH}$	$(24.5 \pm 9) \cdot 10^{-10}$	$\sim 2.7\,\sigma$ with e^+e^-, $< 1\sigma$ using τ (DEHZ)